NORTHEAST OHIO REGIONAL SEWER DISTRICT

2017 Mill Creek Highland Golf Course Restoration Environmental Monitoring: Biological, Water Quality, and Habitat Survey Results

Photo: Mill Creek golf course on June 15, 2017, River Mile 11.52

Prepared by
The Water Quality and Industrial Surveillance Division

Introduction

In 2017, the Northeast Ohio Regional Sewer District (NEORSD) conducted stream monitoring activities at two sites on Mill Creek at Highland Park Golf Course, a tributary to the Cuyahoga River. NEORSD assessed habitat and water chemistry conditions and evaluated the health of the fish and benthic macroinvertebrate communities at each site. The purpose of the monitoring was to evaluate how the restoration project completed in November 2016 affected the general health of the creek. The two sites were located within the restoration area along Mill Creek's Main Branch at river miles (RMs) 11.52 and 10.70. These sites were selected to provide a representative overview of the restoration project area.

The Mill Creek Restoration Project included the restoration of approximately 4,336 linear feet (LF) of Mill Creek, 181 LF of an un-named tributary to Mill Creek, and construction of 1.2 acre floodplain wetland depressions in place of an existing pond (Figures 1-3). The project also resulted in the permanent placement of stream fill in approximately 3,546 LF in Mill Creek and an un-named Mill Creek tributary. Post-restoration monitoring of the habitat was required under the permit; fish and macroinvertebrate surveys were also completed to compare to data collected prior to the restoration project.

Stream monitoring activities were conducted at each site by NEORSD Level 3 Qualified Data Collectors certified by Ohio Environmental Protection Agency (EPA) in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessment as explained in the NEORSD Study Plan *2017 Mill Creek and Highland Restoration Environmental Monitoring* approved by Ohio EPA on May 12, 2017. The results obtained from these assessments were evaluated using the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), and Invertebrate Community Index (ICI). Water chemistry data was validated per the methods outlined by the Ohio EPA (2015) and compared to the Ohio Water Quality Standards (Ohio EPA, 2017) to determine attainment of applicable uses. An examination of the biological information was used in conjunction with the water quality data and QHEI results in order to assess the health of the stream and to show any temporal as well as spatial trends.

Figure 4 is a map of the sampling locations on Mill Creek Highland Restoration Golf Course, and Table 1 lists the sampling locations and their respective river mile, latitude/longitude, site description, and surveys conducted. A digital photo catalog of the sampling locations is available upon request by contacting the NEORSD Water Quality and Industrial Surveillance (WQIS) Division.

Figure 1. Mill Creek Restoration Area

Figure 2. Pond at approximately RM 11.10 (2015)

Figure 3. Constructed wetland depression in place of drained pond (2017)

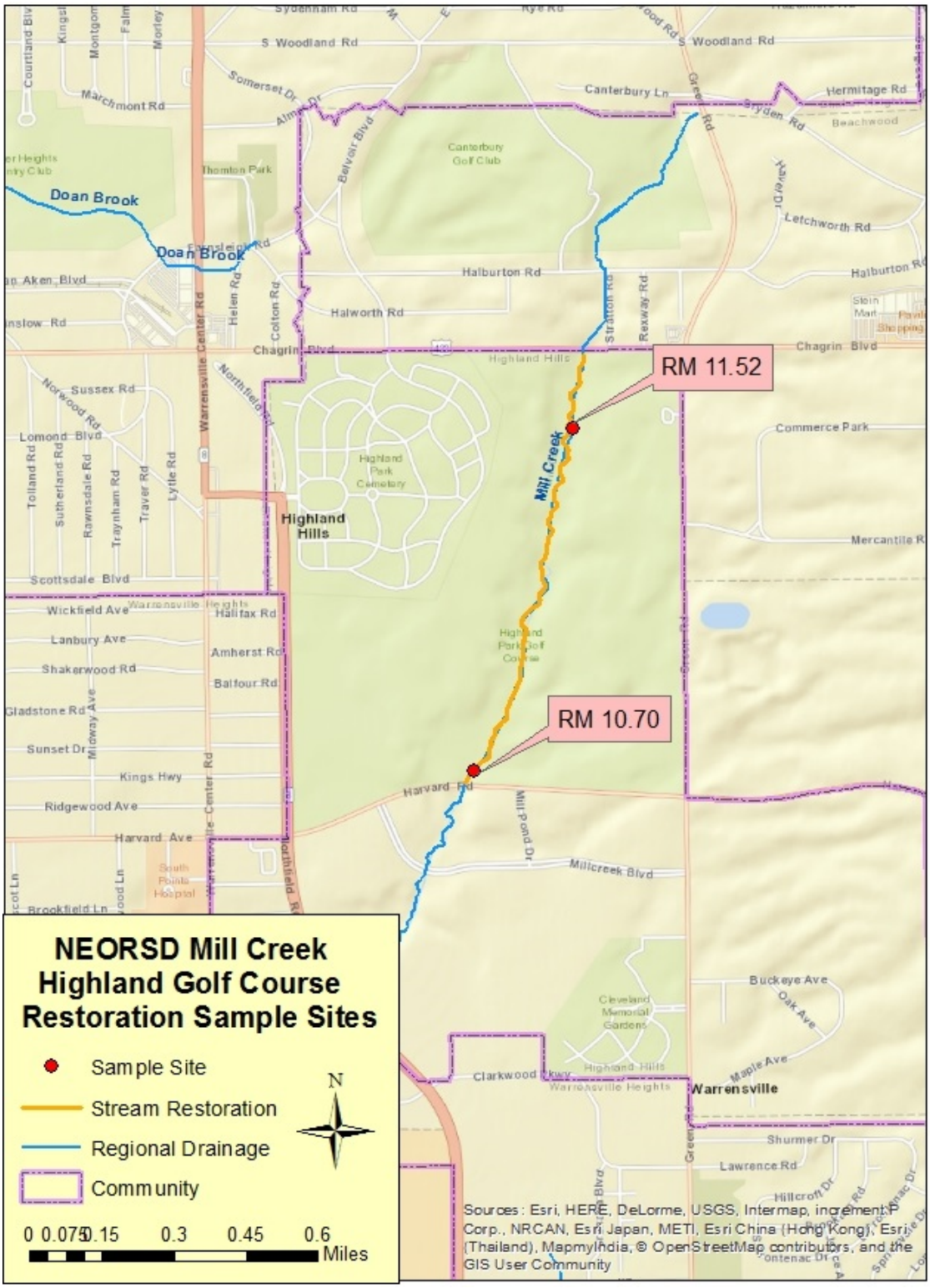


Figure 4. Sampling Locations

Table 1. Mill Creek Sampling Locations					
Location	**Latitude**	**Longitude**	**River Mile**	**Location Information**	**Purpose[1]**
Mill Creek	41.4621	-81.5214	11.52	Within the area of the restoration project	Evaluate overall watershed health after restoration
Mill Creek	41.4518	-81.5255	10.70	Within the area of the restoration project	Evaluate overall watershed health after restoration
[1] Water Chemistry, habitat, fish, and benthic macroinvertebrates were evaluated at each site.					

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times on Mill Creek at RMs 11.52 and 10.70 in 2017. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual* (2015). Chemical water quality samples from each site were collected with a 4-liter disposable polyethylene cubitainer with a disposable polypropylene lid, three 473-mL plastic bottles and a 125-mL plastic bottle. The first 473-mL plastic bottle was field preserved with trace nitric acid, the second was field preserved with trace sulfuric acid and the third bottle received no preservative. The sample collected in the 125-mL plastic bottle (dissolved reactive phosphorus) was filtered using a 0.45-µm PVDF syringe filter. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles preserved with sodium thiosulfate. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using an YSI 600XL or EXO1 sonde. Duplicate samples and field blanks were each collected at randomly selected sites, at a frequency not less than 5% of the total samples collected. Relative percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate sample (Formula 1).

Formula 1:
$$RPD = \left(\frac{|X-Y|}{((X+Y)/2)} \right) * 100$$

X= is the concentration of the parameter in the primary sample

Y= is the concentration of the parameter in the duplicate sample

The acceptable percent RPD is based on the ratio of the sample concentration and detection limit (Formula 2) (Ohio EPA, 2015).

Formula 2: Acceptable % RPD = $[(0.9465X^{-0.344})*100] + 5$

X = sample/detection limit ratio

Those RPDs that are higher than acceptable may indicate potential problems with sample collection and, as a result, the data was not used for comparison to the water quality standards.

Water chemistry analysis sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

Both sites on Mill Creek are designated as warmwater habitat (WWH), agricultural water supply, industrial water supply, and primary contact recreation waters. Over the course of sampling in 2017, there was one duplicate sample collected on July 12, 2017, at RM 10.70. The duplicate had one parameter that was rejected due to an RPD that were greater than the acceptable RPD (Table 2). There are numerous reasons for why parameters needed to be rejected, such as the collector mishandling the sample, environmental heterogeneity, inconsistent sampling methods and/or analytical errors.

Table 2. 2017 Duplicate samples with greater than acceptable RPDs

Date	River Mile	Parameters	Acceptable RPD (%)	Actual RPD (%)	Qualifier
7/12/2017	10.70	Al (Aluminum)	37.4	42.3	Rejected

On July 15, 2017, there was one field blank collected at RM 11.52. Table 3 lists water quality parameters that were rejected or estimated based on Ohio EPA (2015b) data validation protocol. Potential reasons for the contamination of field blanks are inappropriate sample collection, handling, contaminated blank water and/or bottles.

Table 3. 2017 Data Qualified Based on Applicable Field Blank Comparison			
RM	**Date**	**Parameter**	**Qualifier Added**
11.52	06/15/2017	Cr (chromium)	Rejected
11.52	06/15/2017	DRP	Estimate
10.70	06/15/2017	Cr (chromium)	Rejected
10.70	06/15/2017	DRP	Rejected

Paired parameters were compared to one another for QA/QC purposes. Three sets of paired parameters were listed as estimates in 2017 (see Table 4). These were for total solids and total dissolved solids results for the samples. There were no exceedances according to the results for the sampling, so qualification of the data did not impact the water quality evaluation at the site.

Table 4. Unacceptable Paired Parameter RPDs					
River Mile	**Date**	**Paired Parameters**	**Acceptable RPD (%)**	**Actual RPD (%)**	**Qualifier**
11.52	6/28/2017	TS/TDS	13.2	3.0	Estimate
11.52	7/5/2017	TS/TDS	13.0	0.2	Estimate
11.52	7/12/2017	TS/TDS	13.5	2.7	Estimate

Mercury analysis for all of the sampling events was completed using EPA Method 245.1. The detection limit for this method is above the criteria for the Human Health Nondrinking and Protection of Wildlife Outside Mixing Zone Averages (OMZA), so it generally cannot be determined if the sites were in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above the detection limit. Based on the sampling that was completed, mercury was not present at levels above those normally found in the watershed (USEPA, 2004), as all were below the detection limit.

Mill Creek currently has a recreational use designation as Primary Contact Recreation. The criteria for this is based on a statistical threshold value (STV); the *E. coli* cannot be over 410 colony counts per 100 milliliters in more than ten percent of the samples take over a 90-day period and a 90-day geometric mean; the *E. coli* cannot be greater than 126 colony counts per 100 mL. For the 2017 data, Tables 5 shows the *E. coli* results and exceedances of the STV; furthermore, Tables 6 shows the 90-day geomean. In 2017, the *E. coli* densities exceeded the STV criterion during four sampling events at RM 11.52, and during three sampling events at RM 10.70. Both RM 11.52 and RM 10.70 had *E. coli* densities exceeding the 90-day geomean criterion for all five sampling events.

Compared to the most recent (2011) observed *E. coli* density at RM 11.52, the overall *E. coli* density had little to no change. The *E. coli* density at RM 10.70 has significantly reduced since 2011. There are many possibilities to why there was a decrease in *E. coli* densities; for instance, one reason may be due to the constructed wetland depression that is located upstream of RM 10.70. There may also be less wild animals in the area, the stormwater had less *E. coli*, eliminated illicit discharges, or septic systems are being corrected or eliminated.

Table 5. 2017 Mill Creek Highland Golf Course Restoration
***E. coli* Results (most probable number (MPN)/100 ml)**

Date	RM 11.52	RM 10.70
06/15/2017*	2942	5560
06/21/2017*	2018	473
06/28/2017	180	131
07/05/2017	460	186
07/12/2017*	2347	1371

Exceeds STV criterion for 90-day period starting on that day
*Wet-weather event

Table 6. 2017 Mill Creek Highland Golf Course Restoration
90-day geomean

Date	RM 11.52	RM 10.70
06/15/2017*	1029.0	614.8
06/21/2017*	791.3	354.5
06/28/2017	579.2	322.1
07/05/2017	1039.0	505.0
07/12/2017*	2347.0	1371.0

Exceeds geomean criterion for 90-day period starting on that day
*Wet-weather event

No other exceedances were found when the Mill Creek results were compared to the water quality standards that apply.

In 2015, the Ohio EPA Nutrients Technical Advisory Group released a proposed Stream Nutrient Assessment Procedure (SNAP) designed to determine the degree of impairment in a stream due to nutrient enrichment. SNAP assigns designations for quality of surface waters based on factors including dissolved oxygen (DO) swings, benthic chlorophyll *a*, total phosphorous, and dissolved inorganic nitrogen (Ohio EPA, 2015a). NEORSD did not assess DO swings or benthic chlorophyll *a* in 2017; however, nutrients were assessed.

Table 7 shows the results of two sites and the calculated geometric mean for 2017. In 2017, according to the SNAP table, RM 11.52 had nutrient levels which yielded a narrative described as "levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges". Nutrient data from RM 10.70 yielded a narrative of "background levels typical of least disturbed conditions". Based on these results, nutrients should not be causing any significant impacts to the biological communities at those locations.

Table 7: 2017 Nutrient results for Mill Creek used for SNAP analysis.

RM 11.52						
Sample Date	6/15/2017	6/21/2017	6/28/2017	7/5/2017	7/12/2017	**GeoMean**
Total Phosphorus (mg/L)	0.126	0.092	0.09	0.07	0.075	0.089
DRP (mg/L)	0.068	0.06	0.064	0.043	0.05	0.056
Dissolved Inorganic Nitrogen (mg/L)	0.624	1.087	0.716	0.403	0.926	0.711
RM 10.70						
Sample Date	6/15/2017	6/21/2017	6/28/2017	7/5/2017	7/12/2017	**GeoMean**
Total Phosphorus (mg/L)	0.058	0.045	0.034	0.024	0.0345	0.037
DRP (mg/L)	No data	0.022	0.017	0.011	0.0115	0.014
Dissolved Inorganic Nitrogen (mg/L)	0.236	0.799	0.402	0.022	0.1575	0.192

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site on Mill Creek in 2017 using the QHEI. The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species by evaluating the physical attributes of a stream. The index is based on six metrics: stream substrate, instream cover, channel morphology, riparian zone and bank condition, pool and riffle quality, and stream gradient. The QHEI has a maximum score of 100, and a score of 55 or more suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2006). A more detailed description of the QHEI can be found in Ohio EPA's *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

The 2017 QHEI scores for each of the sites are shown in Table 8. During the study, the RM 11.52 and 10.70 sites met Ohio EPA's target score of 55 for headwater sites. Having a score of 55 or above indicates that these sites have a habitat that should be capable of supporting a community of warmwater fish. According to the Ohio EPA, if the score is above 70, the site is considered to be in excellent condition.

Table 8. 2017 Mill Creek Highland Golf Course Historic QHEI scores

Year	RM 11.52	RM 10.70
2009*	48.25	47.00
2011*	55.50	51.00
2017	59.00	60.00
* Score obtained for pre-restoration monitoring		

In 2017, the stream segment at RM 11.52 received a QHEI score of 59, correlating to narrative rating of "*Good*". The substrate at this reach consisted of boulders and cobble; boulders was the predominate substrate. The instream cover had a small amount of overhanging vegetation and pools, and a moderate number of boulders. This part of the creek's channel was moderately stable, the sinuosity was moderate, and the development was relatively good. Additionally, the channel was recently recovered from the restoration activities, and there was none to little bank erosion on both sides of the bank. The velocity in the reach was moderate to slow.

The stream segment at RM 10.70 received a QHEI score of 60, correlating to narrative rating of "*Good*". The substrate consisted of boulders and cobble, with cobble being the predominate substrate. The instream cover had a small amount of overhanging vegetation, pools, boulders, logs and woody debris. The channel at RM 10.70 was moderately stable, the sinuosity was moderate, and the development was relatively good. The channel was recently recovered, and there was none to little bank erosion on both sides of the bank. The velocity in the reach was moderate to slow.

Both RMs 11.52 and 10.70 had QHEI scores improve since the pre-restoration monitoring in 2009 and 2011. The scores may have increased because the restoration project increased the habitat heterogeneity of Mill Creek by re-constructing the channels to add meanders and broadening and improving the quality of the riparian zone.

Electrofishing

Methods

One quantitative electrofishing pass was conducted at each site in 2017. A list of the dates when the surveys were completed is given in Table 9. The creek is small and did not have the flow measured using a United States Geological Survey gage station. Sampling was conducted using longline techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream. The sampling zone was 0.15 kilometers for each site. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

Table 9. Sampling Dates

Date	Sites sampled (RMs)	Method
06/29/2017	11.52	Longline
06/29/2017	10.70	Longline

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of the Ohio EPA Index of Biotic Integrity (IBI). The IBI incorporates 12 community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12. The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional, Good, Marginally Good, Fair, Poor* or *Very Poor* (Table 10). The 12 metrics utilized for headwater are listed in Table 11.

Table 10: IBI Ranges for EOLP Ecoregion							
Ohio EPA Narrative*	Very Poor	Poor	Fair	Marginally Good	Good	Very Good	Exceptional
IBI Score	12-17	18-27	28-35	36-39	40-45	46-49	50-60
	Non-Attainment			Attainment			
*Narrative scores for headwater sites							

Table 11. IBI Metrics (Headwater)
Total Number of Native Species
Number of Darters & Sculpins
Number of Headwater Species
Number of Minnow Species
Number of Sensitive Species
Percent Tolerant Species
Percent Pioneering Species
Percent Omnivores
Percent Insectivores
Number of Simple Lithophils
Percent DELT Anomalies
Number of Fish

Lists of the species, numbers, pollution tolerances and incidence of DELT anomalies for fish collected during the electrofishing passes at each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

On July 29, 2017, one electrofishing pass was conducted at Mill Creek RM 11.52. During the pass, 9 goldfish (*Carassius auratus*) were collected. Goldfish are a non-native species and it is unknown how they were introduced into the creek, though it is likely that they were released into the stream by pet owners. RM. 11.52 received an IBI score of 12, which is the lowest possible IBI score, correlating to a narrative rating of *Very Poor* (Table 12).

One electrofishing pass was also conducted at Mill Creek RM 10.70 on June 29, 2017. Three *Semotilus atromaculatus* (creek chub) and two *Rhinichthys atratulus* (blacknose dace) were obtained during the electrofishing pass. Creek chubs and blacknose

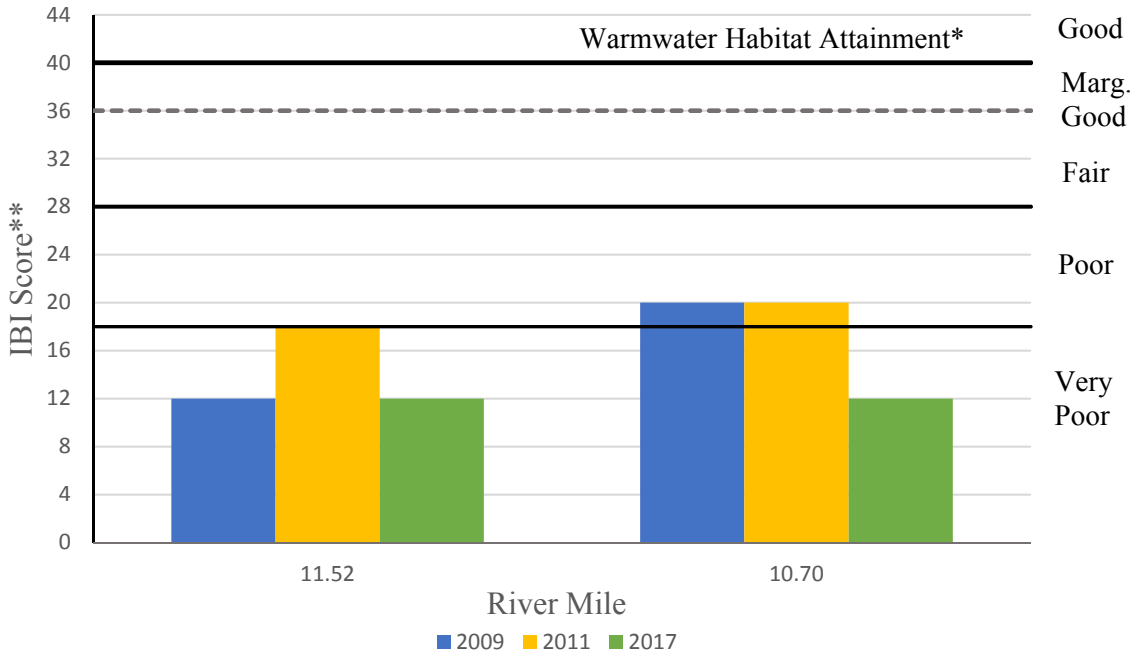
dace are highly tolerant to pollution. RM. 10.70 also received an IBI score of 12, correlating to a narrative rating of *Very Poor*.

Table 12. 2017 Mill Creek IBI Results

River Mile	Pass	Date	IBI Score	Narrative Rating	Total No. of Species	No. of Native Species	% Tolerant Species	No. of fish collected
11.52	1	6/29/2017	12	*Very Poor*	1	0	100	9
10.70	1	6/29/2017	12	*Very Poor*	2	2	100	5
WWH Criterion IBI units ≥ 40 Non-significant departure from WWH criterion ≥36 IBI units								

Both RMs 11.52 and 10.70 had decreased IBI scores since the pre-restoration monitoring (Figure 5). In 2011, RM 11.52 received an IBI score of 18, which was the highest score the site has received in the three sampling seasons. The metrics that contributed to the higher score in 2011 were Proportion of Pioneering Species and Proportion with DELTs. Additionally, 2011 was the only year where the number of individuals collected was over 25. In 2009 and 2011, RM 10.70 received IBI scores of 20. The only two metrics receiving scores above 1 for both years were Proportion of Omnivores and Proportion with DELTs. A total of 795 individuals were collected in 2009 and 567 individuals in 2011, while only 5 individuals were collected in 2017. The decreased scores are potentially due to the continuing recovery process of the creek. Several factors contribute to the recovery of fish populations post stream restoration including the return and stabilization of macroinvertebrate and macrophyte populations, habitat structures, riparian zones, and water levels. Even with improved water quality, Mill Creek Falls acts as a fish barrier downstream of the sampling sites that may be preventing fish migration to the restoration area, limiting the recovery potential at the two sampling sites.

Figure 5. Mill Creek Historic IBI Scores



* Nonsignificant departure is (≤ 4 IBU units) from criterion
** Minimum IBI score is 12 IBI units

Macroinvertebrate Sampling Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa, inhabiting available habitats at the time of HD retrieval. Sampling was conducted at all of the locations listed in Table 1. Methods for sampling followed the Ohio EPA's Biological Criteria for the Protection of Aquatic Life, Volume III (1987b). The recommended period for HDs to be installed is six weeks.

The macroinvertebrate samples were sent to Third Rock Consulting (TRC) of Lexington, Kentucky for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as defined by the Ohio EPA (1987b). Lists of the species collected during the quantitative and qualitative sampling at each site are available upon request from the NEORSD WQIS Division.

The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA's Invertebrate Community Index (ICI) (Ohio EPA, 1987a, 2014a, 2014b). The ICI consists of ten community metrics (Table 13), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while Metric 10 is based on the qualitative EPT taxa. The total of the individual metric scores result in the overall score. This scoring evaluates the community against Ohio EPA's reference sites for each specific eco-region (Table 14).

Table 13. ICI Metrics	
1.	The total number of taxa on HD.
2.	Total number of Ephemeroptera taxa on HD.
3.	Total number of Trichoptera taxa on HD.
4.	Total number of Dipteran taxa on HD.
5.	Percent of Ephemeroptera in HD sample.
6.	Percent Trichoptera in HD sample.
7.	Percent Tribe Tanytarsini midges in HD sample.
8.	Percent Dipterans (excluding Tribe Tanytarsini) and all non-insects in HD sample.
9.	Percent Tolerant organisms (as defined by metric) in HD sample.
10.	Total number of Ephemeroptera, Plecoptera and Trichoptera collected in the qualitative sample.

Table 14: Invertebrate Community Index (ICI) Range for EOLP Ecoregion								
Ohio EPA Narrative	Very Poor	Poor	Low Fair	Fair	Marginally Good	Good	Very Good	Exceptional
ICI Score	0-6	8-12	14-20	22-28	30-32	34-40	42-44	46-60
	Non-Attainment				Attainment			

Results and Discussion

The WWH ICI criterion in the EOLP ecoregion is 34. A site is considered in non-significant departure if it is within 4 ICI units of the criterion and therefore would also be in attainment. The ICI score at RM 11.52 was calculated at 24, giving the site a *Fair* narrative rating (Table 15). RM 11.52 did not meet the WWH attainment status (Ohio EPA 1987b). The ICI score at RM 10.70 was calculated at 24, which correlates to a *Fair* narrative rating and did not meet the WWH attainment status.

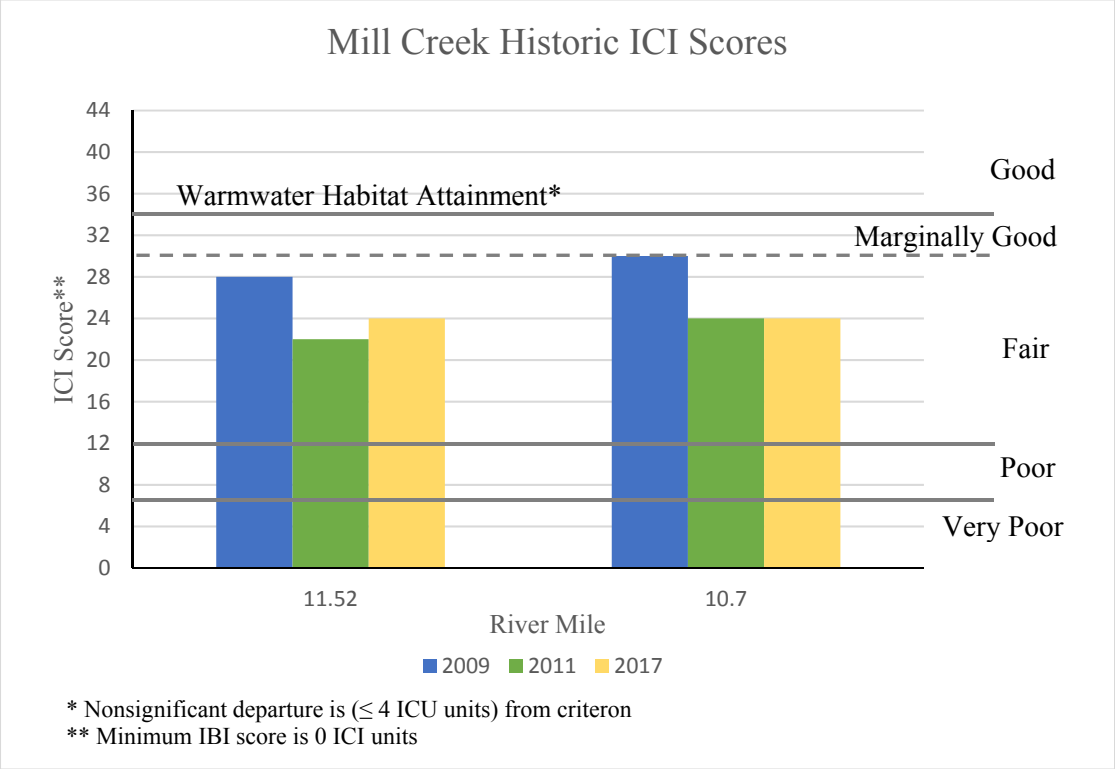
Table 15. 2017 Macroinvertebrate Results						
River Mile	**ICI Score**	**Narrative Rating**	**Total Number of Taxa**	**Number of Qualitative Taxa**	**Number of Qualitative EPT Taxa**	**Number of Qualitative Sensitive Taxa**
11.52	24	*Fair*	34	23	1	0
10.70	24	*Fair*	29	17	2	0
WWH criterion is ≥ 34 ICI units Non-significant departure from WWH criterion is ≥30 ICI units --- not applicable						

The macroinvertebrate community collected with the HD at RM 11.52 consisted of 5,166 organisms representing 34 taxa. Two caddisfly taxa, *Hydroptila* sp. and *Cheumatopsyche* sp., were collected, comprising 0.08% of the sample. Fifteen dipteran taxa were collected, which contributed a score of 4 for the number of dipteran metric. The sample consisted of 46.34% Tanytarsini midges, which contributed a score of 6 for that metric. A high relative abundance of tolerant organisms, including Oligochaeta, *Cricotopus bicinctus*, and *Physa* sp., gave Metric 9 a score of 2. This site had one qualitative EPT taxa, *Baetis flavistriga*, which resulted in a score of zero. There were no stoneflies collected at this site.

A total of 2,355 organisms were collected in the quantitative sample at RM 10.70, including one mayfly taxa, *Baetis flavistriga*, and one caddisfly taxa, *Hydroptila* sp. Mayflies and caddisflies comprised 0.08% and 1.06% of the population respectively. Tanytarsini midges comprised 28.15% of the population, giving Metric 7 a score of 6. RM 10.70 had a similar abundance of tolerant organisms (20.89%) as RM 11.52 and contributed the same score of 2 to that metric. While this site had two qualitative EPT taxa, *Baetis flavistriga* and *Hydropsyche depravata group*, the metric still had a score of zero.

RM 11.52 had a slight increase in ICI score since the pre-restoration monitoring, while RM 10.70 had no change in score (Figure 6). RM 11.52 received its highest ICI score in 2009, though the reach has never been in attainment of WWH criterion in any of the three years of sampling. The increase in ICI score from 2011 to 2017 can be attributed to higher scores in the following metrics; Total Number of Taxa, Percent Tanytarsini Midges, Percent Other Diptera and Non-Insects, and Percent Tolerant Organisms. In 2011, a higher percent of mayflies and caddisflies were collected from RM 11.52 than in 2017. In 2009, RM 10.70 was in non-significant departure from WWH criteria. The most significant differences in the sample composition from 2009 to 2011 and 2017 were the decreased Percent Other Diptera and Non-insects and the decreased Percent Tolerant

Organisms. There were small changes in the composition of the sample from 2011 to 2017, including a higher Percent Tanytarsini Midges and smaller number of Qualitative EPT taxa in 2017.



Conclusions

In 2017, two sites within the Mill Creek Highland Golf Course Restoration area were monitored to evaluate the overall health of the creek post restoration. During the sampling in 2017, both RMs 11.52 and 10.70 were in non-attainment of the biocriteria for Aquatic Life Use Status (Table 16).

Table 16. 2017 Mill Creek Survey Results

River Mile	Aquatic Life Use Attainment Status	IBI Score	ICI Score	Habitat	Water Quality Exceedances
11.52	NON	12	24	59	*E. coli*
10.70	NON	12	24	60	*E. coli*
Warmwater Habitat Criteria		40	34		
Nonsignificant Departure From Criteria		≤4	≤4		
Target				55	

Water chemistry sampling conducted at the sites showed exceedances of applicable water quality standards for *E. coli* in 2017. The *E. coli* densities at both RMs 11.52 and 10.70 have decreased since 2011, although that is likely due to the fact that 2011 was the wettest year on record for Cleveland, with over 60 inches of precipitation (NOAA, 2012). *E. coli* exceedance are an indication of sanitary sewage within the creek and were directly related to wet weather prior to several of the sampling events in 2011 and 2017; densities were lower during dry weather. Potential sources of pollution include illicit discharges, stormwater runoff, and flow from upstream tributaries.

The QHEI scores at both RMs 11.52 and 10.70 have increased since 2011, which is largely due to the restoration project. The habitat at these sites should be able capable of supporting fish communities based on the QHEI scores, yet fish communities at both RMs 11.52 and 10.70 received narratives of *Poor* during the sampling events in 2017. The fish assemblage consisted only of pollution tolerant species including blacknose dace, creek chubs, and goldfish. The IBI scores at both sites have decreased since the pre-restoration monitoring in 2009 and 2011. A possible reason for the lack of improvement in IBI scores is because the fish communities are still recovering from the ecological stressors of the restoration project. Several factors contribute to the recovery of fish assemblages post stream restoration including the return and stabilization of macroinvertebrate and macrophyte populations, habitat structures, riparian zones, and channel stability. The fish populations may improve in time, though there are limitations to the recovery potential due to a waterfall downstream of the restoration site.

A narrative rating of *Fair* was designated to both RMs 11.52 and 10.70 for the ICI and both sites failed to meet the ICI WWH biocriterion (Ohio EPA 1987b). Sanitary sewage contamination, low velocity flows, fertilizer runoff from the golf course, and extensive urbanization upstream of the sampling sites may be contributing factors to the poor macroinvertebrate community assemblage in Mill Creek. Additionally, the restoration project may have placed ecologic stressors on the macroinvertebrate community which may have contributed to the low ICI score. The restoration project along with larger scale capital improvement projects in the watershed will hopefully have a positive influence on the biology, water quality, and habitat of Mill Creek in the future.

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